PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 :
A61B 3/00

A1

(11) International Publication Number: WO 00/54655

(43) International Publication Date: 21 September 2000 (21.09.00)

(21) International Application Number: PCT/US00/05835

(22) International Filing Date: 6 March 2000 (06.03.00)

(30) Priority Data:
09/267,523 12 March 1999 (12.03.99) US

(71) Applicant: BAUSCH & LOMB SURGICAL, INC. [US/US]; 555 West Arrow Highway, Claremont, CA 91711 (US).

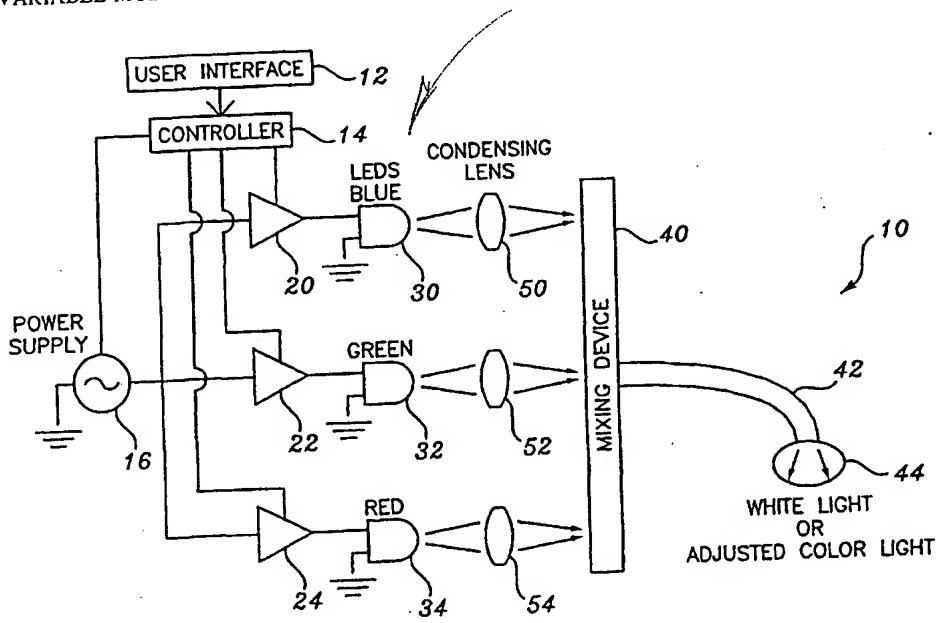
(72) Inventor: NEUBERT, William, J.; 1118 Windyoak Drive, Ballwin, MO 63021 (US).

(74) Agents: SMITH, Michael, L. et al.; Bausch & Lomb Incorporated, One Bausch & Lomb Place, Rochester, NY 14604-2701 (US).

(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: VARIABLE MULTIPLE COLOR LED ILLUMINATION SYSTEM



(57) Abstract

An ophthalmic illumination system is provided that emits a light that is controllably variable in color. Because the light originates from LEDs, less heat is generated the emitted light as compared to conventional ophthalmic illumination systems using tungsten or discharge sources.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania
AM	Armenia
AT	Austria
AU	Australia
AZ	Azerbaijan
BA	Bosnia and Herzegovina
BB	Barbados
BE	Belgium
BF	Burkina Faso
BG	Bulgaria
BJ	Benin
BR	Brazil
BY	Belarus
CA	Canada
CF	Central African Republic
CG	Congo
CH	Switzerland
CI	Côte d'Ivoire
CM	Cameroon
CN	China
CU	Cuba
CZ	Czech Republic
DE	Germany
DK	Denmark
EE	Estonia
ES	Spain
FI	Finland
FR	France
GA	Gabon
GB	United Kingdom
GE	Georgia
GH	Ghana
GN	Guinea
GR	Greece
HU	Hungary
IE	Ireland
IL	Israel
IS	Iceland
IT	Italy
JP	Japan
KE	Kenya
KG	Kyrgyzstan
KP	Democratic People's Republic of Korea
KR	Republic of Korea
KZ	Kazakstan
LC	Saint Lucia
LI	Liechtenstein
LK	Sri Lanka
LR	Liberia
LS	Lesotho
LT	Lithuania
LU	Luxembourg
LV	Latvia
MC	Monaco
MD	Republic of Moldova
MG	Madagascar
MK	The former Yugoslav Republic of Macedonia
ML	Mali
MN	Mongolia
MR	Mauritania
MW	Malawi
MX	Mexico
NE	Niger
NL	Netherlands
NO	Norway
NZ	New Zealand
PL	Poland
PT	Portugal
RO	Romania
RU	Russian Federation
SD	Sudan
SE	Sweden
SG	Singapore
SI	Slovenia
SK	Slovakia
SN	Senegal
SZ	Swaziland
TD	Chad
TG	Togo
TJ	Tajikistan
TM	Turkmenistan
TR	Turkey
TT	Trinidad and Tobago
UA	Ukraine
UG	Uganda
US	United States of America
UZ	Uzbekistan
VN	Viet Nam
YU	Yugoslavia
ZW	Zimbabwe

Variabl Multiple Color LED Illumination Syst m

Background of the Invention

1. *Field of the Invention*

This invention relates to illumination systems that are used in conjunction with ophthalmic surgery for illuminating ocular tissue. More specifically, this invention provides an illumination system that can provide varying color and intensity.

2. *Related Art*

Currently, illumination systems for illuminating ocular tissue use tungsten, discharge, or fluorescent lamps. These light sources give off a great deal of heat. This heat must be removed by adding cooling fans to the equipment. In addition, because the tungsten and fluorescent lamps convert a significant fraction of the incoming power to heat, a large power supply is required to drive the lamps. The added cooling fans and larger power supply increases the cost of the illumination system.

A tungsten light source has a longevity of approximately 50 hours and produces an extremely bright, hot light.

Ophthalmic surgeons conduct anterior and posterior segment surgery. In general, ophthalmic surgeons will specialize by performing only anterior segment surgery, or by performing only posterior segment surgery. No surprisingly, due to the variation in tissue and due to the depth of surgery,

ophthalmic surgeons have varying preferences on the color of light provided by an illumination system. Ophthalmic surgeons conducting anterior segment surgery have a tendency to prefer an illumination system that will deliver a yellow-red light, while ophthalmic surgeons conducting posterior surgery have a tendency to prefer an illumination system that provides a white-blue light.

In order to accommodate these varying preferences, a rather extensive offering of light filters has been devised to vary the color output of a light source. Thus, one or more light filters must be selected and installed proximate the light source of an illumination system. However, there is variation in the initial color outputs between illumination systems. One tungsten light source may put out an unfiltered light that is slightly different in color from another tungsten light source from thee same manufacturer. Thus, what may be the correct filtering choice for a first illumination system may not achieve similar results when the same light filters are installed in a second illumination system. Accordingly, the selection of light filters might not result in the desired color output without some experimentation.

Summary of the Invention

It is in view of the above problems that the present invention was developed. The invention is a variable, multiple color, LED (Light Emitting Diode) ophthalmic illumination system that permits control over variation in color and intensity of the light output. As an additional benefit, less heat is generated because LEDs are highly efficient. In addition, LEDs are more

reliable. A tungsten light source will last approximately fifty (50) hours. However, a LED light source has a longevity of approximately 20,000 hours. Due to the configuration of the illumination system of the present invention, control over the color of the light output can be strictly controlled. Stated alternatively, the present invention can control the color of the light output such that a yellower light or a bluer light or a redder light is produced. This control eliminates the necessity of selecting among multiple light sources, depending on the procedure, and among multiple filters. In addition, the present invention provides a lower heat output as compared to ophthalmic illumination systems of the prior art.

Further features and advantages of the present invention, as well as the structure and operation of various embodiments of the present invention, are described in detail below with reference to the accompanying drawings.

Brief Description of the Drawings

The accompanying drawings, which are incorporated in and form a part of the specification, illustrate the embodiments of the present invention and together with the description, serve to explain the principles of the invention. In the drawings:

Figure 1 illustrates a schematic view of the ophthalmic illumination system of the present invention.

Detailed Description of the Preferred Embodiments

Referring to the accompanying drawings in which like reference numbers indicate like elements, Figure 1 illustrates the ophthalmic illumination system shown generally at 10 of the present invention. The illumination system of the present invention includes user interface 12, controller 14, power supply 16, first power amplifier 20, second power amplifier 22, third power amplifier 24, first light emitting diode (LED) 30, second LED 32, third LED 34, mixing device 40, and exit lightguide 42. Preferably, and thus shown in Figure 1 but not required, is first condensing lens 50, second condensing lens 52 and third condensing lens 54. Preferably, first LED 30 is a blue LED, second LED 32 is a green LED, and third LED 34 is a red LED. However, other LED colors are conceivable, such as blue, yellow or red. In general, three LEDs or sources of different emitting wavelength are required. It is also conceivable that more than three LEDs or more than three wavelengths may be used.

In operation, a user inputs the desired light intensity and/or color into user interface 12. Based on the demanded light intensity and/or color, controller 14 determines the appropriate power level and amplifier gain for each LED. The determination of the color ratios and intensities that are required to produce a desired color output are well known. The blue, green and red sources are the same color sources that are used to produce color in television sets. Additional discussion of the measurement and analysis of color is provided in The Photonics Design and Applications Handbook (1997), pp. H-52 to H-60, and is hereby incorporated by reference in its entirety. In addition, the

determination of the color ratios and intensities that are required to produce a desired color output are provided as a CEI standard, as described in ASTM E308-95 "Standard Practice for Computing the Colors of Objects Using the CIE System" which is hereby incorporated by reference in its entirety.

After determining the proper color ratios and intensities, controller 14 sends power signal to power supply 16, a first gain signal to first power amplifier 20, a second gain signal to second power amplifier 22, and a third gain signal to third power amplifier 24.

As a result, first LED 30, second LED 32, and third LED 34 emit light. Preferably, but not required, the light from first LED 30 is condensed by first condensing lens 50; the light from second LED 32 is condensed by second condensing lens 52; and the light from third Led 34 is condensed by third condensing lens 54. Condensing lenses are used commonly in telecommunications systems and are widely available. Condensing lenses may take many forms, and range from crude single element molded plastic devices to multi-element aspherical precision assemblies. The purpose of a condensing lens is to focus the diffuse light emitted by each LED.

Upon the light's entering and then exiting from the condensing lenses 50, 52, and 54, light enters mixing device 40. Mixing device 40 is any device that will mix light from multiple sources and are well known in the lightguide arts. Examples of mixing device 40 include glass rods, bifurcated or trifurcated fiber optic cables, integrating spheres, or the like.

Upon exiting from mixing device 40, the light enters into exit lightguide 42. Exit lightguide 42 is then inserted into ocular tissue 44 to provide illumination for surgical procedures.

Unlike the fifty (5) hour life span of a tungsten light source, the illumination system of the present invention contemplates a life span of approximately twenty thousand (20,000) hours. Accordingly, the present invention provides increased reliability over tungsten light sources due to increased life span, less heat generated as compared to tungsten light sources, and the ability to select a color output in an ophthalmic illumination system by inputing a color output selection into a user interface.

In view of the foregoing, it will be seen that the several advantages of the invention are achieved and attained.

The embodiments were chosen and described in order to best explain the principles of the invention and its practical application to thereby enable others skilled in the art to best utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated.

As various modifications could be made in the constructions and methods herein described and illustrated without departing from the scope of the invention, it is intended that all matter contained in the foregoing description or shown in the accompanying drawings shall be interpreted as illustrative rather than limiting. For example, condensing lenses may be eliminated such that the LEDs 32, 34, and 36 emit light directly to mixing device 40. Alternatively, mixing device 40 may simultaneously incorporate a condensation

of light from LEDs 32, 34, and 36 without the use of a separate condensing lens elements 50, 52, and 54. Thus, the breadth and scope of the present invention should not be limited by any of the above-described exemplary embodiments, but should be defined only in accordance with the following claims appended hereto and their equivalents.

What is Claimed Is:

1. An ophthalmic illumination system comprising:

a first light emitting diode;

a second light emitting diode;

a third light emitting diode;

whereby each of said diodes emits a different light wavelength so that at least three different wavelengths of light are emitted from said first, second and third diodes to illuminate ocular tissue.

2. an ophthalmic illumination system comprising:

a first light emitting diode;

a second light emitting diode;

a third light emitting diode;

a mixing device for mixing light emitted from said first, second and third light emitting diodes together; and

an exit lightguide in light communication with said mixing device, said exit lightguide adapted for insertion into ocular tissue.

3. an ophthalmic illumination system according to claim 2, wherein said first light emitting diode emits the color blue, said second light emitting diode emits the color green, and said third light emitting diode emits the color red.

4. An ophthalmic illumination system according to claim 2, wherein said first light emitting diode emits the color blue, said second

light emitting diode emits the color yellow, and said third light emitting diode emits the color red.

5. An ophthalmic illumination system according to claim 2, further comprising:

a first condensing lens in light communication with said first light emitting diode and said mixing device;

a second condensing lens in light communication with said second light emitting diode and said mixing device; and

a third condensing lens in light communication with said first light emitting diode and said mixing device.

6. An ophthalmic illumination system according to claim 2, further comprising:

a user interface for permitting a user to input a desired color output;

a controller connected to said user interface for determining how much light should be emitted from each of said light emitting diodes to produce the desired color output;

a first gain amplifier connected to said first light emitting diode;

a second gain amplifier connected to said second light emitting diode;

a third gain amplifier connected to said third light emitting diode;

said controller connected to said first gain amplifier, said second gain amplifier, and said third gain amplifier; and

whereby said controller sends a first gain signal to said first gain amplifier, a second gain signal to said second gain amplifier, and a third gain signal to said third gain amplifier to adjust the output of each of said light emitting diodes to produce the desired color output.

7. A method of illuminating ocular tissue comprising:

providing a user interface for inputting a desired color output;

providing a first LED, a second LED, and a third LED;

providing a mixing device in light communication with said first, second and third LED that mixes the light emitted by each;

providing an exit lightguide in light communication with said mixing device for illuminating ocular tissue;

providing a controller to adjust the output of each of said LEDs to produce a desired color output; and

whereby a desired color output input into said user interface results in that color output from said exit lightguide.

8. A method of illuminating ocular tissue according to claim 7, further comprising:

providing a first gain amplifier having an output connected to said first LED and connected to said controller;

providing a second gain amplifier having an output connected to said second LED and connected to said controller; and

providing a third gain amplifier having an output connected to said third LED and connected to said controller.

9. A method of illuminating ocular tissue according to claim 7, further comprising:

providing a first condensing lens in light communication with said first LED and said mixing device;

providing a second condensing lens in light communication with said second LED and said mixing device; and

providing a third condensing lens in light communication with said third LED and said mixing device.

10. A method of illuminating ocular tissue comprising:

inputting a desired color output into a user interface of an ophthalmic illumination system;

producing the desired color output automatically from the ophthalmic illumination system to illuminate ocular tissue.

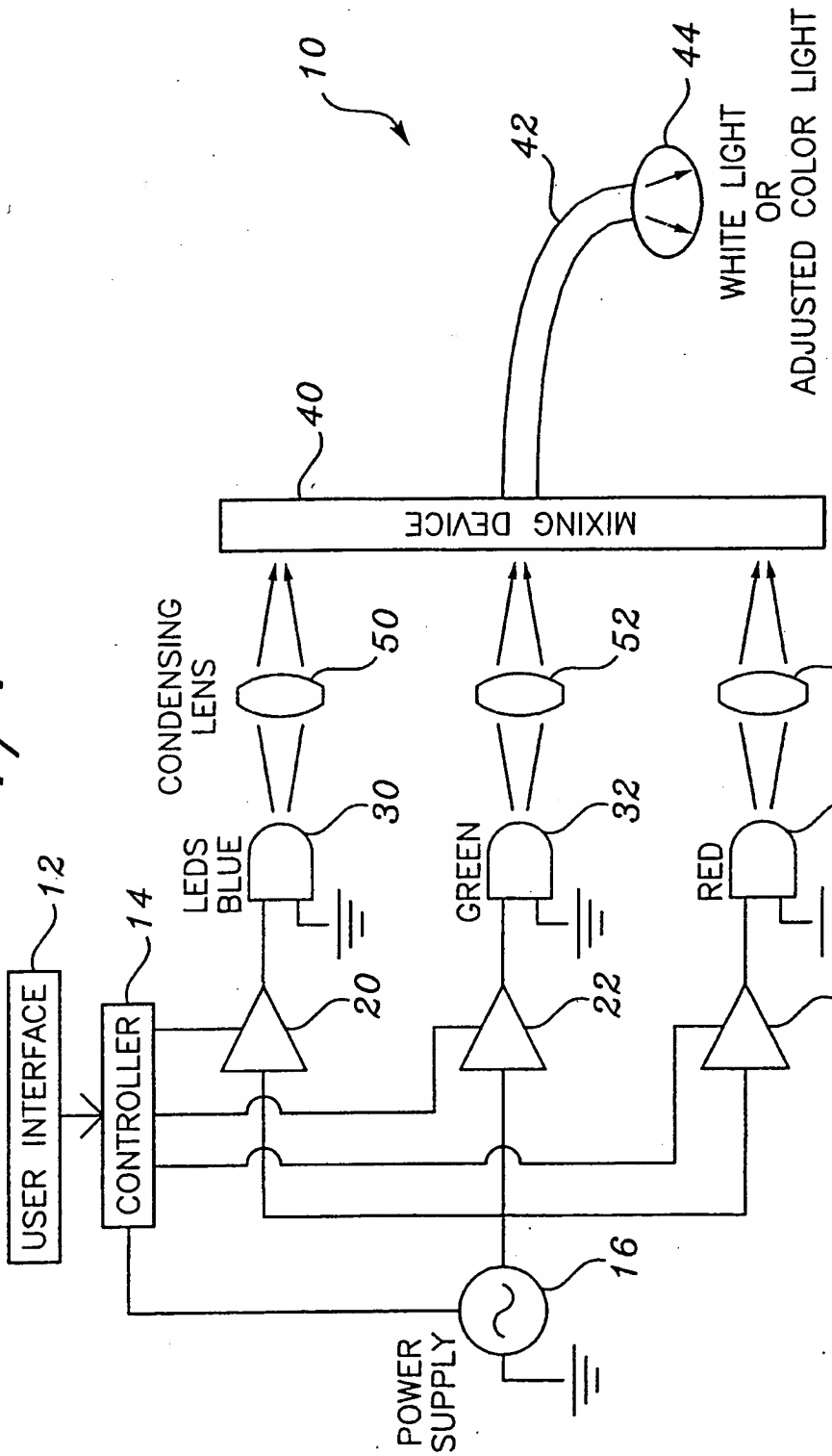

10
44
42
WHITE LIGHT
OR
ADJUSTED COLOR LIGHT
40
MIXING DEVICE
CONDENSING
LENS
50
52
54
LEDS
BLUE
30
GREEN
32
RED
34
12
14
USER INTERFACE
CONTROLLER
20
22
24
16
POWER
SUPPLY

figure 1

1/1

INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/US 00/05835

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61B3/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 96 05693 A (APPLITEC LTD ;MERON GABRIEL DAVID (IL); FRAIER ISRAEL (IL)) 22 February 1996 (1996-02-22)	1
Y	page 7, line 5 -page 8, line 20; claims; figures	2-4,6-8, 10

X	EP 0 838 866 A (GEN ELECTRIC) 29 April 1998 (1998-04-29)	1
A	page 2, line 3 - line 22 page 4, line 14 - line 55	2-10

Y	EP 0 501 034 A (CERAMOPTEC GMBH) 2 September 1992 (1992-09-02) column 5, line 54 -column 6, line 31; figures	2-4,6-8, 10

	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
7 June 2000	20/06/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Manschot, J

1

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Inter . ›nal Application No
PCT/US 00/05835

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 641 349 A (FLOM LEONARD ET AL) 3 February 1987 (1987-02-03) column 10, line 66 -column 11, line 37; figures 10,11	1
A	US 4 699 482 A (UTSUGI KATSUHIKO) 13 October 1987 (1987-10-13) column 3, line 67 -column 4, line 24; claim 2; figure 1	5,9

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inten nal Application No
PCT/US 00/05835

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9605693 A	22-02-1996	AU 3258095 A	07-03-1996
EP 0838866 A	29-04-1998	US 5851063 A	22-12-1998
		CN 1185042 A	17-06-1998
		JP 10209504 A	07-08-1998
EP 0501034 A	02-09-1992	US 5632740 A	27-05-1997
US 4641349 A	03-02-1987	AT 65851 T	15-08-1991
		BR 8605561 A	22-04-1987
		CA 1244552 A	08-11-1988
		DE 3680618 A	05-09-1991
		EP 0215818 A	01-04-1987
		IL 77920 A	30-06-1989
		JP 5084166 B	01-12-1993
		JP 62501889 T	30-07-1987
		MX 163339 A	24-04-1992
		WO 8605018 A	28-08-1986
US 4699482 A	13-10-1987	JP 1751581 C	08-04-1993
		JP 4031691 B	27-05-1992
		JP 59000038 A	05-01-1984